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Bureau des brevets



## Canadian Patent

## Brevet canadien

1183834

**To all to whom these presents shall come:**

Whereas a petition has been presented to the Commissioner of Patents praying for the grant of a patent for a new and useful invention, the title and description of which are contained in the specification of which a copy is hereunto attached and made an essential part hereof, and the requirements of the Patent Act having been complied with,

Now therefore the present patent grants to the applicant whose title thereto appears from the records of the Patent Office and as indicated in the said copy of the specification attached hereto, and to the legal representatives of said applicant for a period of seventeen years from the date of these presents the exclusive right, privilege and liberty of making, constructing, using and vending to others in Canada the invention, subject to adjudication in respect thereof before any court of competent jurisdiction.

Provided that the grant hereby made is subject to the conditions contained in the Act aforesaid.

In testimony whereof, these letters patent bear the signature of the Commissioner and the seal of the Patent Office hereunto affixed at Hull, Canada.

**A tous ceux qui les présentes verront:**

Considérant qu'une requête a été présentée au Commissaire des brevets, demandant la délivrance d'un brevet pour une invention nouvelle et utile, dont le titre et la description apparaissent dans le mémoire discriptif dont copie est annexée aux présentes et en fait partie essentielle, et que ladite requête satisfait aux exigences de la Loi sur les brevets,

A ces causes, le présent brevet confère au demandeur dont le titre de propriété audit brevet est établi d'après les dossiers du Bureau des brevets et est indiqué dans ladite copie du mémoire descriptif ci-annexé, et aux représentants légaux du dit demandeur, pour une période de dix-sept ans, à compter de la date des présentes, le droit, la faculté et le privilège exclusif de fabriquer, construire, exploiter et vendre à d'autres au Canada l'invention, sauf jugement en l'espèce par un tribunal de juridiction compétente.

La concession faite par les présentes étant soumise aux conditions contenues dans la loi précitée.

En foi de quoi ces lettres patentes portent la signature du Commissaire ainsi que le sceau du Bureau des brevets apposé à Hull, Canada.

MAR 12 1985

Commissioner of Patents    Commissaire des brevets

Attesting Officer    Certificateur

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Consommation et Corporations Canada

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# (19) (CA) CANADIAN PATENT (12)

(54) Flat Plate Heat Exchanger

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The greatly increased use of both passive and active solar systems to heat water and other liquid and gaseous heat transfer mediums has heightened the demand for a small, relatively inexpensive, yet efficient heat exchanger. One noteworthy attempt at such a heat exchanger is that which forms the subject matter of U.S. Patents Nos. 3,705,618; 3,854,530; and 3,823,458. A spirally-wrapped sheet interlaced with flow-directing baffles functions as the tube bundle of the exchanger when the edges thereof are welded and it is housed in a suitable jacket. The rubber baffle-forming member can be designed to produce various types of flow such as, for example, axial, spiral or crossflow. Integrally-formed dimples on the spirally-wound sheet are arranged in staggered relation and they cooperate to keep the flow paths open between the convolutions of the spiral.

Clever as the above-described spiral heat exchanger is, it still costs a good deal to manufacture due to the spiral construction. The working fluids must be filtered and kept quite free of particulates or the unit becomes quite susceptible to clogging with the resultant loss in heat transfer efficiency. Also, the efficiency of the unit in the range of 1000 BTU/hr/$ft^2$ of heat transfer surface, while superior to that of most tubular units, still needs improvement.

It has now been found in accordance with the teaching of the instant invention that these and other shortcomings of the prior art unit can be improved upon, if not eliminated altogether, by the simple, yet unobvious expedient of rearranging the exchanger into the form of a stacked laminate of flat rectangular plates interlaced with baffle-forming elements alternating in reversed relation to define adjacent countercurrent flow paths. Integrally-formed dimples in the plates may be used as required to maintain

the spaced relation therebetween as before in those areas having no baffle elements functioning as separators. The sides and ends of the stack are welded as before with those welds cooperating with the internal baffling to define the generally M-shaped fluid-flow path. A considerable cost saving is effected by eliminating the usual double-walled insulated jacket found in most tubular heat exchangers. In place thereof, simple collars and headers are welded onto the corners of the parallel plate module to direct fluid into and receive fluid from the latter. The resulting unit is very compact and efficient, one a foot long, some four inches wide and an inch and a half thick providing very nearly four square feet of heat transfer area.

It is, therefore, the principal object of the present invention to provide a novel and improved parallel plate heat exchanger.

A second objective is the provision of a device of the type aforementioned which is even more compact and efficient than its spirally-wrapped counterparts of similar construction.

Another object is to provide a flat plate laminated heat exchanger module that uses similarly-shaped baffles between alternate plates that are flopped over side-for-side so as to cooperate with the like baffle or baffles adjacent thereto to define a more or less M-shaped countercurrent flow path as the two fluids migrate from one end to the other in heat exchange relation.

Still another objective is the provision of a heat exchange module which can be sized to meet various throughput demands by merely increasing or decreasing the size of the sandwich-like stack of plates and baffle inserts.

An additional object is to provide a heat exchanger of the type herein disclosed and claimed which can be designed to accommodate different flow rates in the two fluids by just changing the thickness and size of the baffle elements.

Further objects are to provide a miniature welded parallel plate heat exchanger module that is compact, rugged, versatile, lightweight, easy to fabricate and even somewhat decorative.

Broadly stated, the invention is a parallel plate heat exchanger which comprises: a plurality of flat rectangular metal plates, baffle-forming elements for insertion between each pair of plates cooperating therewith in stacked relation to maintain a fixed spaced parallel relation therebetween and a generally M-shaped fluid flow path from an inlet at one end thereof to an outlet at the other, and means at said inlet and outlet ends for distributing one of two heat transfer mediums among the parallel flow paths available thereto at said inlet and for collecting same at said outlet, the baffle-forming elements of any one tier within said stack being reversed side-for-side with respect to the baffle-forming elements in an adjacent tier so as to define inlets and outlets on the opposite side for the other of said heat transfer mediums and to direct the latter in countercurrent flow relation to the first.

Other objects will be in part apparent and in part pointed out specifically hereinafter in connection with the description of the drawings that follows, and in which:

Figure 1 is a plan view, portions of which have been broken away to more clearly reveal the interior construction, showing the baffle arrangement and countercurrent flow paths within adjacent laminations;

Figure 2 is a longitudinal section taken along line 2--2 of Figure 1;

Figure 3 is a transverse section, taken along line 3--4 of Figure 2; and,

Figure 4 is a perspective view to a somewhat larger scale than Figures 1 - 3, again with portions broken away to expose the interior thereof and reveal the countercurrent flow patterns therethrough.

Referring next to the drawings for a detailed description of the present invention, reference numeral 10 has been chosen to represent the parallel plate heat exchanger in its entirety and it will be seen to include, among other features, a set of two or more flat rectangular metal plates 12 and another set of baffle-forming elements that have been broadly identified by reference numerals 14C and 14E. With one of the plates on both the top and bottom, a multi-tiered stack S is built up of alternating plates 12 and baffle-forming elements 14. In the preferred form of this unit, spacer-forming dimples 16 are provided in the surface of the plates to maintain the opposed areas between two such plates remote from any boundary wall 18 or partition wall 20 of the baffle elements in fixed spaced relation to one another.

With specific reference to Figs. 1 and 4, baffle-forming element 14C will be seen to be generally C-shaped and include a short boundary-defining sidewall 18S terminating at each end in an inside partition wall 20S of a length substantially less than the width of plate 12 so as to leave a gap 22 between it and long sidewall 18L of baffle element 14E. The length of short sidewall 18S of baffle element 14C is, likewise, considerably shorter than the overall length of plate 12 such that gaps 24 are left between the short partition walls 20S at the ends thereof and long boundary-forming endwalls 18E of the generally E-shaped baffle element 14E. The latter baffle element 14E, in addition to its long sidewall 18L and endwalls 18E, has a center partition wall 20C located between the aforementioned endwalls of a length considerably less than the overall width of plate 12 so as to leave yet another gap 26 between it and the boundary wall 18S across therefrom.

Now, with continued reference to Figs. 1 and 4, it will be seen that the larger of the baffle elements 14E are all essentially the same in

that long boundary wall 18L extends the full length of plate 12 while endwalls 18E do likewise across the ends thereof. In the particular form illustrated, gap 26 of the odd-numbered tiers counting down from the top is somewhat narrower than the corresponding gap 26W of the even-numbered tiers. In similar fashion, gaps 22 and 24 of the odd-numbered tiers are narrower than the analogous gaps 22W and 24W of the even-numbered ones, as shown. This is easily accomplished in the case of the larger of the two baffle-forming elements 14E by merely cutting off partition wall 20C to produce shorter partition wall 20CM. By so doing, modified baffle-forming elements 14EM in the even-numbered tiers are primarily foreshortened but considerably thicker versions of those 14E of the odd-numbered tiers flopped over side-for-side, all of which is most clearly revealed in Figs. 1 and 2, the former having the baffle-forming elements of the odd-numbered tiers shown unshaded while those of the even-numbered ones are shaded for ease of distinguishing between the two.

In much the same manner, the relatively thicker C-shaped baffle elements 14CM of the even-numbered tiers that cooperate with their E-shaped counterparts 14EM to define the somewhat wider and deeper gaps 22M and 24M all have foreshortened partition walls 20SM at the ends thereof; however, in addition, their boundary wall 18SM is also shortened to move its partitions 20SM closer together. Thus, from a dimensional standpoint, in the preferred form of the invention illustrated, boundary elements 18L and 18E of the E-shaped baffle element 14E are all that remain the same length in both the even-numbered and odd-numbered tiers while all the other elements of the former are both thicker and shorter than the latter.

Now, the whole purpose of this dimensional variation between the odd- and even-numbered tiers is to create a circuitous generally M-shaped flow path around the partition walls 20C, 20CM, 20S and 20SM of the baffle-forming elements that will accommodate a greater rate of flow through the latter than through the former. While all four figures of the drawings show this feature to some extent, Fig. 2 is probably the best. Obviously, the flow paths through the odd- and even-numbered tiers could be made equal to one another with the attendant reduction in manufacturing costs that could be realized by using the same baffle-forming elements 14 in each tier by merely reversing them side-for-side in the odd-numbered tiers as opposed to the even-numbered ones. The preferred version shown has the advantage of two circuits with different capacities that can be tailored to the needs of a particular heat exchange problem somewhat better than a unit which offers no such choice. Water to be heated could, for example, be circulated through the smaller of the two circuits while a solar-heated fluid, even hot air, could be passed in heat exchange relation thereto through the larger circuit.

In Figs. 1, 3 and 4, shaded arrows have been employed to show the flow of the heat transfer fluid (liquid or gas) through the larger flow circuit of the two defined by the even-numbered tiers of subassemblies in stack S while the unshaded arrows do likewise with the smaller flow circuit of the odd-numbered tiers counted, as before, from the top down. In each of these figures, it can be seen that the heat transfer media circulating through these two circuits always moves in countercurrent flow relation to one another although, obviously, by reversing the direction of flow of either one, they can be made to move in cross-flow relation.

These same figures of the drawings (1, 3 and 4) also reveal how the heat transfer mediums entering the heat exchange area are introduced by means of a suitable pipe fitting 28 into a header 30 before being divided and sent along their multiple parallel paths through the exchange area. The same set up is shown at the outlet for collecting and recombining the media in each circuit that has thus been warmed or cooled as the case may be. The larger diameter fittings have been designated 28L to distinguish them from the smaller diameter ones 28S. In like manner, the headers 30S and 30L bear similar letter designations. The portions of the sides between the headers and the ends are shown in Fig. 4 covered by sideplates and endplates 32 and 34, respectively; however, their function is primarily one of decoration since all elements of the assembly including the baffle-forming elements are preferably made of a metal like stainless steel that can be both cold-worked and welded. When the parts exclusive of the side and endwalls are welded up into a complete assembly, the only way the heat exchange media can either enter or leave the unit is through one of the headers 30, therefore, no other casing is needed. If, on the other hand, certain of the elements in the stacked assembly are not weldable, then the side and endwalls may be employed to maintain the fluid-tight integrity of the unit provided, of course, adhesives or some other fastening method is used for this purpose.

Finally, as illustrated, it can be seen that all the plates 12 are not alike in that the dimples 16 pressed into the surface thereof are in different locations on one plate than they are in the plate adjacent thereto. In other words, the dimpling in the odd-numbered plates is different from that in the even-numbered ones so that they lie in offset side-by-side relation as shown in Figs. 1, 2 and 4, not vertically-aligned stacked relation. One skilled in the art will immediately recognize, of course, that all the plates

could be made alike by relocating the dimples such that by merely turning alternate plates upside down, the vertically-aligned relation of the dimples would no longer exist.

What is claimed is:

1. The parallel plate heat exchanger which comprises: a plurality of flat rectangular metal plates, baffle-forming elements for insertion between each pair of plates cooperating therewith in stacked relation to maintain a fixed spaced parallel relation therebetween and a generally M-shaped fluid flow path from an inlet at one end thereof to an outlet at the other, and means at said inlet and outlet ends for distributing one of two heat transfer mediums among the parallel flow paths available thereto at said inlet and for collecting same at said outlet, the baffle-forming elements of any one tier within said stack being reversed side-for-side with respect to the baffle-forming elements in an adjacent tier so as to define inlets and outlets on the opposite side for the other of said heat transfer mediums and to direct the latter in countercurrent flow relation to the first.

2. The parallel plate heat exchanger as set forth in claim 1 wherein: the baffle-forming elements comprise a generally E-shaped member having a long sidewall terminating at opposite ends in two endwalls effective when in place between two plates to seal one side and the ends thereof against the passage of fluid, and a partition spaced between said endwalls extending from the sidewall part way across the plates; and, a generally C-shaped member having a foreshortened sidewall positionable along the side of said plates opposite that occupied by the sidewall of the E-shaped member in spaced substantially parallel relation thereto and spaced inwardly of both endwalls of the latter so as to cooperate therewith in defining said inlet and said outlet, and a pair of partition walls extending from opposite

ends of said foreshortened sidewall part way across the plates in the spaces left open between the endwalls and partition wall of said E-shaped element, said foreshortened sidewall being effective to seal the side of said plates opposite that sealed by the sidewall of the E-shaped element against the passage of fluid and said endwalls cooperating therewith and with the three partition walls therebetween to define the M-shaped flow path.

3. The parallel plate heat exchanger as set forth in claim 1 wherein: the plates each include integrally-formed dimples functioning in stacked relation to maintain a fixed spaced relation between adjacent plates.

4. The parallel plate heat exchanger as set forth in claim 1 wherein: the plates and baffle-forming elements are all made of weldable metal and wherein said elements are welded together in stacked relation to define a unitary structure.

5. The parallel plate heat exchanger as set forth in claim 1 wherein the baffle-forming elements of one set of alternate tiers are thicker than those of the tiers therebetween so as to define a flow path of greater capacity in the former than in the latter.

6. The parallel plate heat exchanger as set forth in claim 2 wherein: the stack includes both even-numbered and odd-numbered tiers, the sidewall and partition walls of the C-shaped elements in one of said odd- and even-numbered tier sets being shorter than the corresponding walls of the other set so as to define relatively wider inlets and outlets as well as the flow path therebetween.

7. The parallel plate heat exchanger as set forth in claim 6 wherein: the partition wall of the E-shaped element is approximately the same length as the partition walls of the C-shaped elements in each tier.

8. The parallel plate heat exchanger as set forth in claim 6 wherein: the baffle-forming elements defining the relatively wider flow paths are also thicker.

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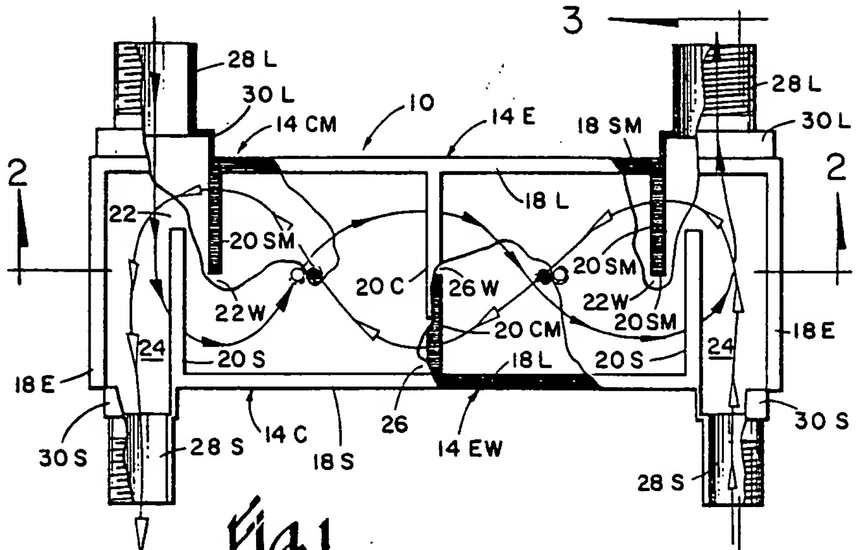


Fig.1

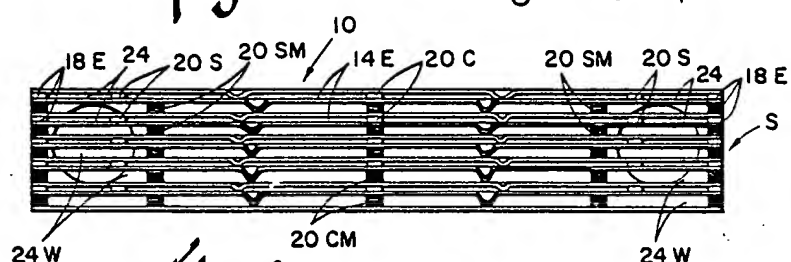


Fig.2

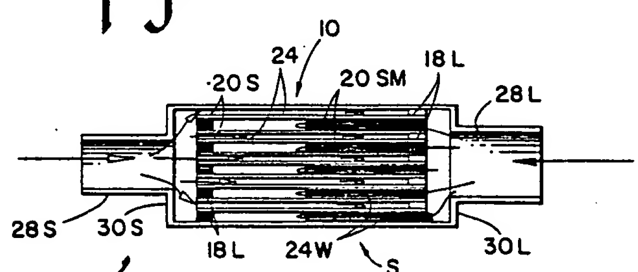


Fig.3

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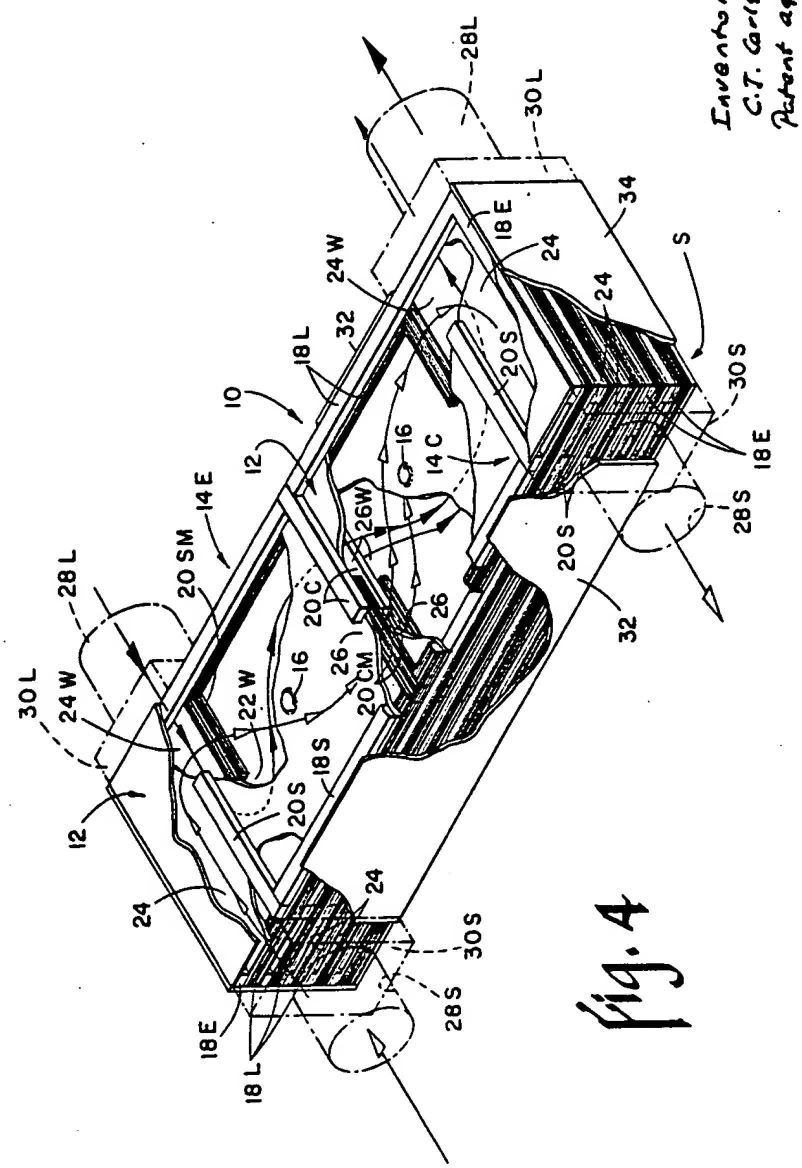


fig.4

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